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Canadian Science Advisory Secretariat
Maritimes Region | Science Response 2017/037

STOCK STATUS UPDATE OF 4VWX HERRING

Context

Maritimes Fisheries and Oceans Canada (DFO) Resource Management has requested that DFO Science provide an update on the science advice for North Atlantic Fisheries Organization Divisions 4VWX Atlantic Herring[1] (*Clupea harengus*) management unit in support of the 2016/2017 fishery. The last assessment of 4VWX herring stock was conducted in March 2015 (DFO 2015) and an update report was completed in 2016 (DFO 2016). The biological and fishery information of the 4VWX herring stock forms the basis for establishing quota for the 2016/2017 fisheries, as required in the Integrated Fisheries Management Plan (IFMP). A review and update of biological and fishery information of the 4VWX herring stock are provided in this Science Response. It includes: an evaluation of the southwest Nova Scotia/Bay of Fundy (SWNS/BoF) spawning component; a compilation and review of information regarding the offshore Scotian Shelf spawning component and the coastal Nova Scotia (NS) spawning component; an update on southwest New Brunswick (SWNB) migrant juvenile fishery component; an evaluation of the status of the fishery with respect to the Limit Reference Point (LRP); and information about whether the goals of the rebuilding plan are being met.

This Science Response Report results from the Science Response Process of April 12, 2017, on the Stock Status Update of Herring in Northwest Atlantic Fisheries Organization (NAFO) Fishing Area 4VWX.

Background

The 4VWX herring management unit contains a number of spawning areas, separated to various degrees in space and time. For the purposes of evaluation and management, the 4VWX herring fisheries are divided into four components (see the Appendix for map of place names):

- SWNS/BoF spawning component (includes Scots Bay, German Bank, and Trinity Ledge)
- Offshore Scotian Shelf spawning component (includes The Patch and Western Hole)
- Coastal NS spawning component (includes South Shore, Eastern Shore, and Cape Breton)
- SWNB migrant juveniles (NB weirs)

Each component, except SWNB migrant juveniles, has several spawning areas, and there is mixing of fish among spawning components outside of the spawning period. The Total Allowable Catch (TAC) for the SWNS/BoF has been 50,000t since 2011. The Offshore Scotian Shelf has an allocation of 12,000t, and the coastal NS fishing areas have allocations based on the recent 5-year average of observed spawning stock biomass (SSB[2]).

The 2003 (Evergreen) Scotia-Fundy Herring IFMP set out principles, conditions, and management measures for the 4VWX herring fisheries (DFO 2003). The main principle stated in the plan is "the conservation of the herring resource and the preservation of all of its spawning

[1] Throughout this document 4VWX Atlantic Herring is referred to as 4VWX herring.
[2] Throughout this document, spawning stock biomass (SSB) refers to the spawning stock biomass observed at the time of the acoustic surveys.

components". The three conservation objectives are: to maintain the reproductive capacity of herring in each management unit, to prevent growth overfishing, and to maintain ecosystem integrity/ecological relationships ("ecosystem balance"). Progress against these conservation objectives was evaluated during the March 2015 assessment (DFO 2015). A major review of the assessment framework was conducted in 2006/2007 (DFO 2007) followed by a final framework meeting in 2011 to review the models. An analytical model was not chosen; however, recommendations for the assessment methodology were provided (DFO 2011). In 2012, a LRP of 371,067t[3], the average SSB in Scots Bay and German Bank for the period 2005-2010, was set (Clark et al. 2012). The total SSB in these two areas is evaluated based on the 3-year moving average of acoustic biomass with respect to this LRP.

The herring fisheries in 4VWX have always been dominated by purse seine (e.g. 81-99%, 1981-2016). Other gear types include weir, gillnet, shutoff, and trap.

Analysis and Response

Landings

The landings for the period October 15, 2015, to October 14, 2016, (the 2015/2016 quota year) were 50,012t against a TAC of 50,000t for the SWNS/BoF component (Table 1).

Table 1. Reported landings (rounded to thousands of tonnes) and total allowable catch for the 4VWX herring management unit by component from 2008 to 2016 with decadal averages from 1970 to 2009.

Year	Avg. 1970 -79	Avg. 1980-89	Avg. 1990-99	Avg. 2000 -09	2008	2009	2010	2011	2012	2013	2014	2015	2016
4WX SW Nova Scotia/ Bay of Fundy TAC[1]	106	106	112	69	55	55	55	50	50	50	50	50	50
4WX SW Nova Scotia/Bay of Fundy[1]	131	131	96	66	55	54	46	50	48	47	50	49	50
4VWX Coastal Nova Scotia[2]	<1	<1	4	7	4	10	6	4	3	4	5	5	8
Offshore Scotian Shelf[2]	38	<0.1	13	6	1	9	12	10	1	2	<0.1	2	1
SW New Brunswick[2]	26	24	24	15	6	4	11	4	1	6	2	<0.2	4
Total Landings	172	155	137	93	66	77	74	68	52	58	57	56	63

1 - Quota year from October 15th of the preceding year to October 14th of the current year
2 - Calendar year from January 1st to December 31st

Additional landings of 12,901t were taken in the non-quota stock components (outside the quota area) for a total of 62,913t. Southwest NB weirs and shutoffs landings in 2016 increased to 4,060t from the historical low of 146t in 2015 (Table 1). The landings decreased for the Offshore Scotian Shelf and remained below the 12,000t allocation for the area. Landings for the 4VWX Coastal NS component, primarily from gillnet gear, increased to 7,805t in 2016 from 5,166t in 2015. Within the SWNS/BoF component, there was a decrease in catches from the German Bank area defined as the acoustic catch box from 42% of the total TAC in 2015 to 40% in 2016. Within this catch area, purse seine fishers decided on a cap of 50% of the TAC in 2013 and 40% in 2014 for implementation in the subsequent fishing years. Landings by defined fishing grounds decreased in 2016 from German Bank, Grand Manan, Lurcher, Scots Bay, NB Coastal, and Trinity Ledge, and increased from Gannet Dry Ledge and Long Island. For SWNS/BoF, landings in 2016 were 988t (2%) greater than in 2015.

[3] This relative spawning stock biomass (SSB) is based on data from acoustic surveys and is not an estimate of the population. The number reported in previous publications was incorrect.

Southwest Nova Scotia/Bay of Fundy

Age Structure

The 2016 fishery landings (by number) were dominated by 2 and 3-year olds (27 and 38% overall, respectively) with widespread occurrence in most areas (Figure 1). The reliance of the fishery on these younger age groups is a cause for concern because many of these fish are still immature. On the main spawning grounds of Scots Bay and German Bank, however, the landings are dominated by mature fish (ages 3+). In the Gannet/Dry Ledge area, the dominant group was Age 3 (39%), while in the Lurcher area the Age 5 group was the largest (40%). By weight, the largest age classes were Age 2 (15%), Age 3 (31%), Age 4 (12%), and Age 5 (15%). Age 3 catches were largest in the month of July, particularly in the Grand Manan Banks, Scots Bay, German Bank, and Gannet/Dry Ledge fishing grounds. An important feature of the 2016 catch-at-age is the dominance of Age 3 (38%) with apparent tracking from the dominant Age 2 in 2015 (40%). There was also a general decrease in terms of numbers and weight for Ages 2, 4 and 6+ when compared to 2015. Ages 7+ decreased from 15% in 2015 to 10% in 2016. Based on the age structure, the total number of fish removed by the fishery in 2016 was estimated to be 32 million fish (7%) more than in 2015. In 2016, a greater number of Ages 3 and 5 fish were landed than in 2015, but the numbers of fish Aged 6 and older in the commercial landings are less than those in the 1965-1995 time period (Figure 2).

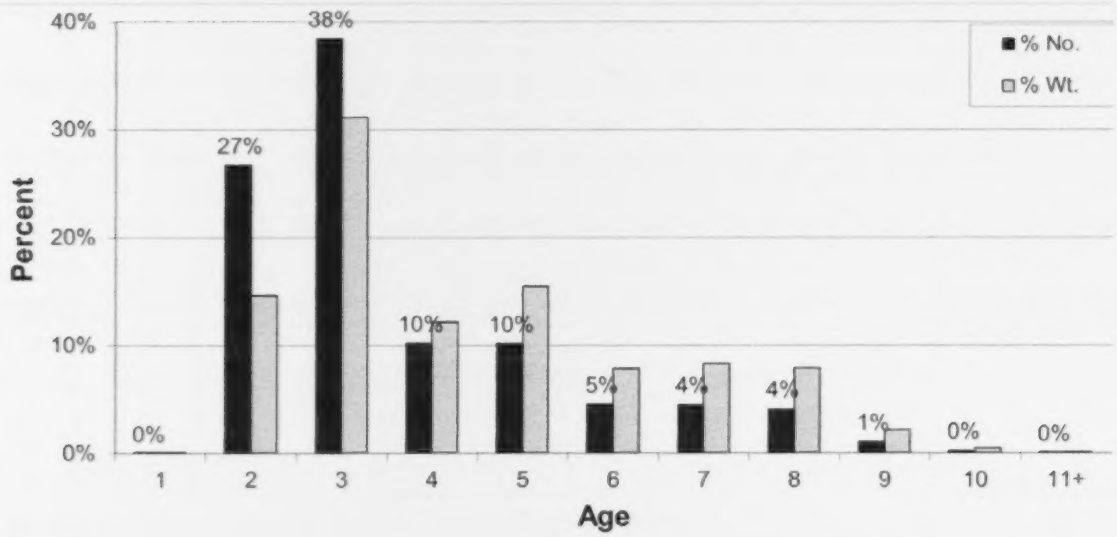

Figure 1. Fishery catch-at-age (percentage numbers and percentage weight) for Southwest Nova Scotia/Bay of Fundy spawning component (2015-2016 quota year).

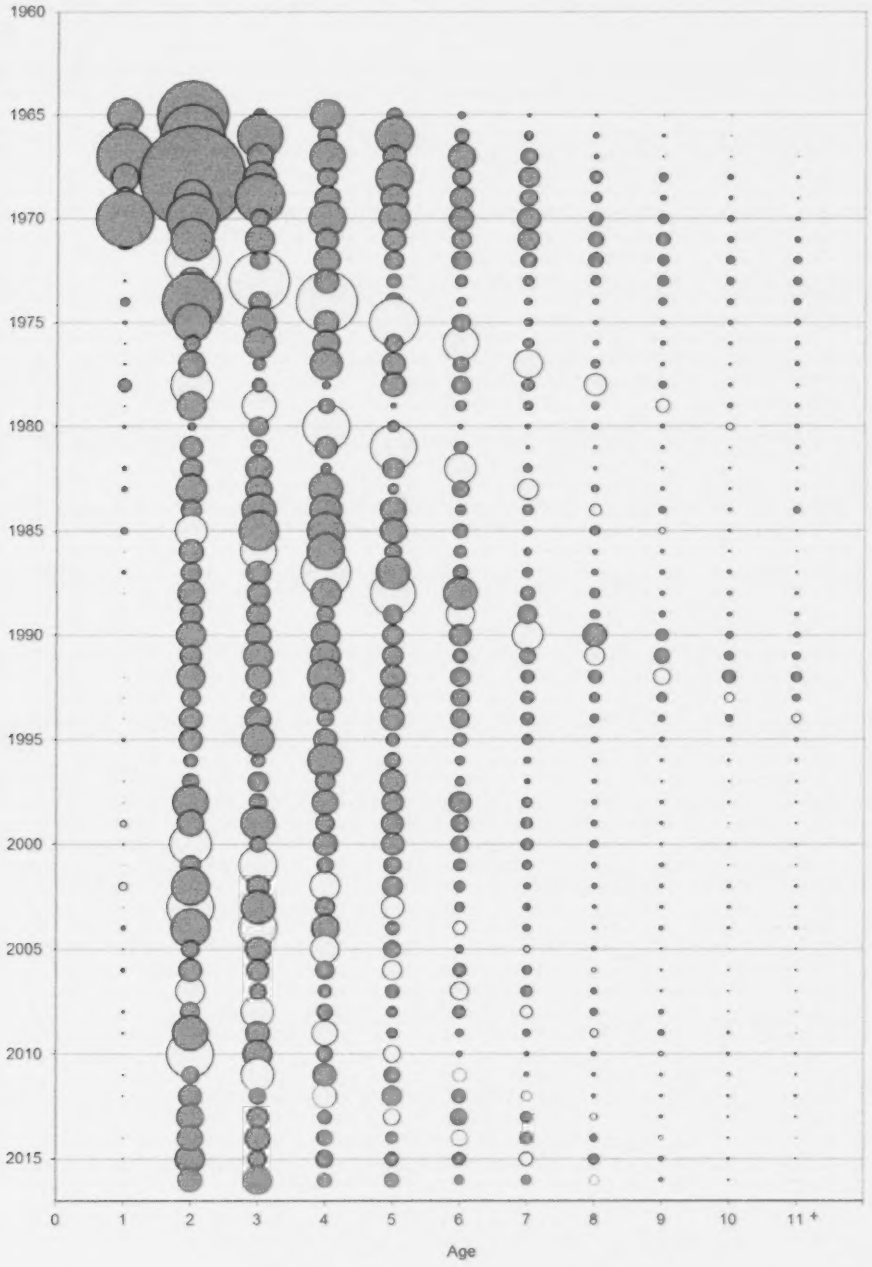

Figure 2. Historical relative numbers-at-age (denoted by circle size) in the commercial landings for Southwest Nova Scotia/Bay of Fundy spawning component from 1965-2016. Selected year-classes are shown in yellow.

The acoustic surveys numbers-at-age continue to have a broad age distribution of spawning fish from Ages 3-11. In the acoustic surveys, the proportion of fish Age 6 and older was 40% (41% in 2014). Since 2010, there has been an increase in proportion of fish Age 6 and older in the acoustic catch-at-age. In the fishery, the proportion of fish Age 6 and older was 14% (23% in

2014), which is substantially lower than the acoustic surveys catch-at-age due to the inclusion of juveniles. In the acoustic surveys, the mean age has decreased slightly to 5.2 years in 2016 from 5.3 years in 2015. Age 3 and 5 fish were most abundant in the 2016 Scots Bay surveys (25% and 24% by number, respectively) followed by Age 7 fish at 12%. German Bank had a wider representation by Ages 3-8 (21-13%, by number) with Age classes 3 and 4 being the largest groups (21% and 20%, respectively). Strong and weak year classes can typically be tracked through the numbers-at-age matrix (Figure 3).

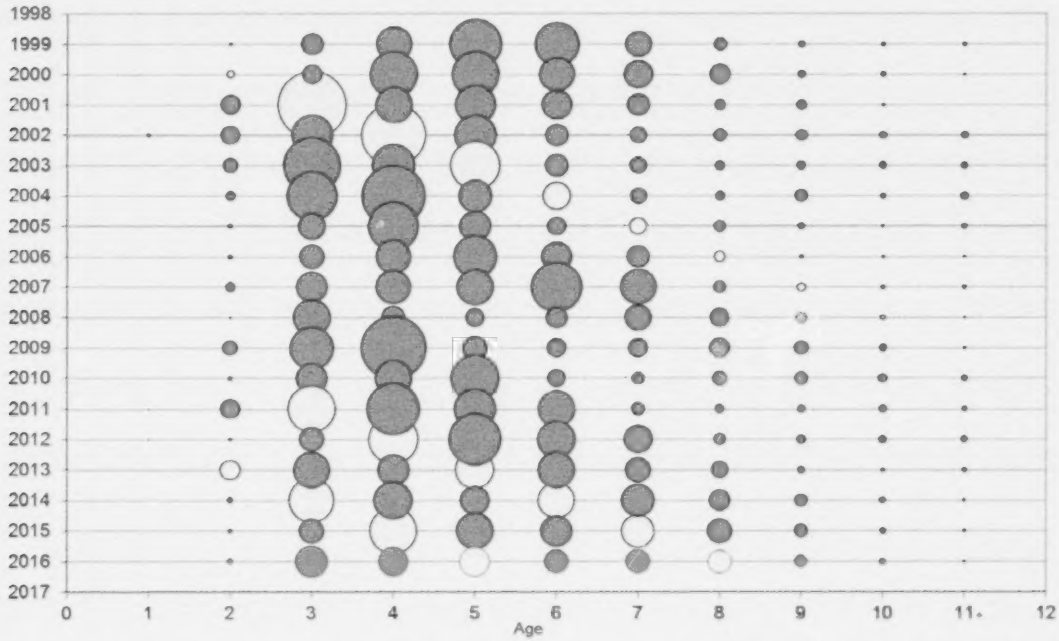

Figure 3. Relative numbers-at-age (denoted by circle size) in the acoustic catch-at-age for Southwest Nova Scotia/Bay of Fundy spawning component from 1999-2016. Selected year-classes are shown in yellow.

Acoustic Surveys

The results of the 2016 acoustic surveys for the SWNS/BoF component are summarized in Table 2. Inbox and outbox refers to survey tracks within and outside the designated survey boxes, respectively. There were 6 surveys in Scots Bay, 5 on German Bank, and 3 on Trinity Ledge. A sixth survey conducted on German Bank was excluded because it was conducted less than 10 days after the previous survey.

The overall acoustic biomass estimates (Scots Bay, Trinity Ledge, and German Bank) decreased to 328,253t (95% confidence interval (C.I.): +/- 25,627t) from 462,241t (95% C.I.: +/- 31,747t) in 2015. This moves the overall acoustic biomass estimate to 26% below the long-term average (1999-2016) of 443,658t. Most of the decrease occurred in Scots Bay with 115,669t (95% C.I.: 17,280t) in 2016 down from the record high of 285,184t (95% C.I. +/- 26,242t) in 2015. The German Bank SSB increased from the 2015 low of 176,389t (C.I.: +/- 41.899t) to 212,078t (95% C.I.: +/-36,210t) in 2016. The 20% increase in the biomass estimate for German Bank, however, does not compensate for the large decrease in Scots Bay of 59%. This decrease in Scots Bay is concerning; however, similar fluctuations in both directions have been previously recorded in this area.

Table 2. Acoustic surveys spawning biomass index for Southwest Nova Scotia/Bay of Fundy spawning component for 1999 to 2016 (rounded to thousands of tonnes).

Location	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average 2005-2010*	Average 1999-2016
Scots Bay (inbox)	46	185	216	129	123	115	21	32	51	23	82	42	106	144	67	221	260	110	42	**110**
Scots Bay (outbox)	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	2	0	6	12	35	41	9	5	25	6	5	**14**
Scots Bay Total	**46**	**185**	**216**	**129**	**123**	**115**	**21**	**32**	**53**	**23**	**88**	**54**	**141**	**185**	**76**	**226**	**285**	**116**	**45**	**117**
German Bank (inbox)	495	334	257	416	349	392	269	291	495	239	396	235	289	278	254	230	176	212	321	**312**
German Bank (outbox)	n/d	n/d	n/d	n/d	n/d	n/d	n/d	5	4	2	2	19	11	10	11	3	0	0	6	**6**
German Bank Total	**495**	**334**	**257**	**416**	**349**	**392**	**269**	**295**	**499**	**241**	**398**	**254**	**300**	**288**	**265**	**233**	**176**	**212**	**326**	**315**
Scots Bay and German Total	541	519	473	546	472	507	290	327	552	264	485	308	441	473	341	459	462	328	371	**433**
Trinity Ledge	4	1	15	9	12	12	11	16	3	1	2	2	7	3	1	5	1	1	6	**6**
Spec Buoy (spring)	n/d	n/d	1	n/d	1	n/d	1	n/d	0	0	n/d	2	0	n/d	n/d	n/d	n/d	n/d	1	**1**
Spec Buoy (fall)	n/d	n/d	88	n/d	n/d	n/d	n/d	0	n/d	n/d	n/d	n/d	n/d	n/d	n/d	0	0	n/d	0	**44**
Overall Stock Area	**545**	**521**	**577**	**554**	**485**	**519**	**301**	**343**	**556**	**265**	**487**	**312**	**449**	**476**	**342**	**464**	**462**	**328**	**377**	**444**
Seal Island	n/d	n/d	4	1	12	n/d	n/d	10	n/d	n/d	n/d	n/d	1	n/d	n/d	n/d	n/d	n/d	10	**6**
Browns Bank	n/d	n/d	45	n/d	n/d	n/d	n/d	8	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	8	**26**
Total All Areas	**545**	**521**	**626**	**556**	**497**	**519**	**301**	**361**	**556**	**265**	**487**	**312**	**450**	**476**	**342**	**464**	**462**	**328**	**380**	**448**

* Note: Average 2005-2010 = Limit Reference Point (German Bank and Scots Bay total only)
n/d = no data for that year in that category
Zero = surveys conducted but the numbers recorded were either 0 or less than 500t (rounds to 0 thousand t)

Limit Reference Point

The 3-year moving average for the acoustic surveys estimate (Scots Bay and German Bank combined) has recently decreased from being 13% above the LRP in 2014 to being 11% above in 2016 (Figure 4). In 2016, the acoustic surveys estimate (327,700t) decreased from 2015 (461,600t). As a result, the value of the 3-year moving average in 2016 (416,200t) also decreased from 2015 (420,500t), resulting in a downward trend in the last two years. This trend is a cause for concern and current management measures may not be adequate to meet the rebuilding plan objectives.

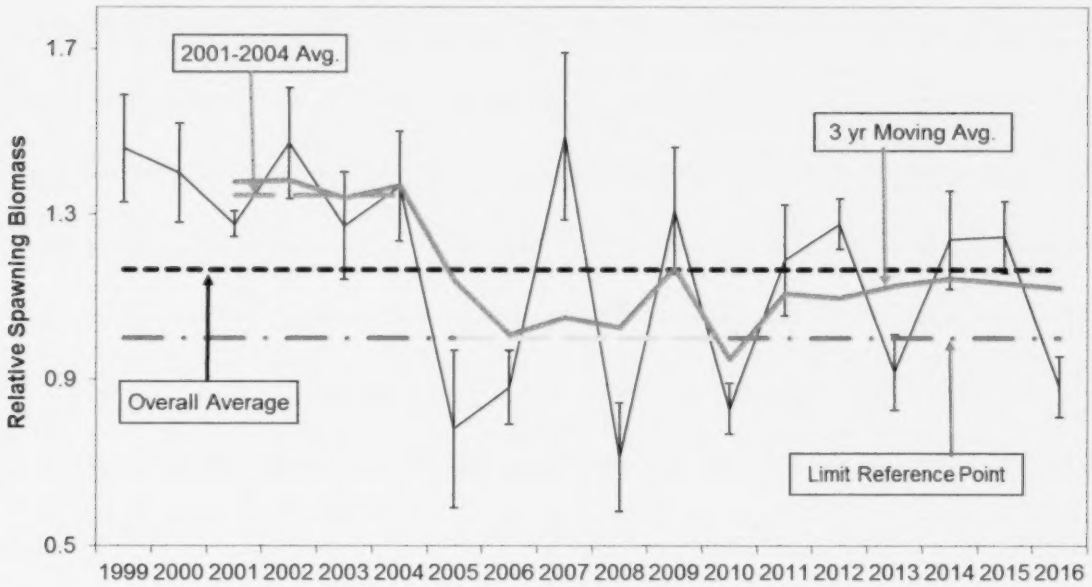

Figure 4. Relative spawning stock biomass index (with 95% standard errors), the calculated 3-year moving average, the overall average since 1999, and the limit reference point for the Southwest Nova Scotia/Bay of Fundy spawning component (German Bank and Scots Bay).

Other Considerations

During November and December 2016, a herring mortality event occurred on the Nova Scotia side of the Bay of Fundy. Most of the event was concentrated in St. Mary's Bay; however, dead herring also washed up in Annapolis Basin and southwest Nova Scotia. The cause of the mortality event remains undetermined. From an acoustic survey in St. Mary's Bay, a biomass of over 11,700t of herring was estimated to be present in the area during the event. The proportion of biomass actually affected is unknown but is likely small. The majority of the dead herring were immature of ages 2 and 3. If the number of fish involved in the mortality event is small, the impact of this event on future SSB is expected to negligible.

Offshore Scotian Shelf Component

In 2016, offshore landings decreased to 1,035t from 1,803t in 2015 (Table 1), and are well below the allocation limit of 12,000t. Most landings were caught by purse seiners in April, May and June, in the vicinity of The Patch and Western Hole (see map in the Appendix). The commercial catch was comprised primarily of adult herring with ages 4, 5, and 6 dominating by numbers (72%) and weights (71%). A by-catch of 35t was reported from groundfish otter trawl

fisheries for Silver Hake on the Scotian Shelf. The DFO Summer Research Vessel survey mean catch-per-tow for the 4WX offshore area decreased from 167 fish in 2015 to 119 fish in 2016.

Coastal Nova Scotia (South Shore, Eastern Shore and Cape Breton) Spawning Component

Allocations for the coastal NS spawning component are based on the recent 5-year average of observed acoustic SSB, where available. Landings in the Little Hope/Port Mouton area increased in 2016 to 5,939t from 4,160t in 2015 against the 2016 allocation of 6,151t (Table 3). In the Eastern Shore area, landings increased in 2016 to 1,837t (from 1,001t in 2015) against the 2016 allocation of 1,884t. In Glace Bay, landings of 4t were reported in 2016. The Bras d'Or Lakes area remained closed to herring fishing. In 2016, the catch for the coastal component consisted primarily of adult herring. This gillnet fishery is size selective with a substantial proportion of the catch (89% by numbers) Age 5 and older. The dominant class was Age 6 at 39% by number.

In 2016, the SSB for the Little Hope/Port Mouton area decreased from the record high of 145,395t in 2015 to 61,408t, which is below the recent 5-year average of 67,926t (Table 4). The SSB in the Halifax/Eastern shore area also decreased from 68,562t (2015) to 54,094t (2016), which is above the recent 5-year average of 28,556t. As in previous years, caution is always warranted in applying the survey SSB as an absolute tonnage of herring in the water.

Since 2013, no survey has been completed in Glace Bay.

Table 3. Recorded landings and allocations (tonnes) of herring from major gillnet fisheries on the Coastal Nova Scotia spawning component for 1999 to 2016.

Landings and Allocations (t)		Avg. 99-05	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Little Hope/Port Mouton	Catch	2,393	3,140	1,510	1,108	3,731	3,106	2,576	2,150	2,499	3,596	4,160	5,939
	Allocation	2,086	3,952	4,008	2,944	2,172	2,454	2,094	2,188	2,790*	3,577	3,772	6,151
Halifax/Eastern Shore	Catch	2,246	3,350	3,720	2,348	5,885	2,302	908	771	1,390	1,163	1,001	1,837
	Allocation	2,255	4,323	5,367	5,103	3,857	4,373	4,188	2,920	2,427	1,959	1,066	1,884
Glace Bay	Catch	1,340	85	45	12	4	11	0	7	2	1	0	4
Bras d'Or Lakes	Catch	54	0	0	0	0	0	0	0	0	0	0	0

*original allocation of 2,387t was increased by 400t

Table 4. Estimated herring acoustic spawning stock biomass (SSB) (tonnes) and recent 5-year average for the Coastal Nova Scotia spawning component areas.

Acoustic Survey SSB (t)	Avg. 98-05	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Avg. last 5 years
Little Hope/Port Mouton	29,088	24,100	2,800	14,500	36,600	26,700	28,796	12,756	74,532	46,077	145,395	61,408	68,034
Little Hope Allocation	2,086	3,952	3,825	2,938	2,295	2,530	2,094	2,188	2,790*	3,577	3,772	6,151	3,615
Halifax/Eastern Shore	31,944	68,900	28,300	30,300	54,200	27,700	5,498	3,668	6,870	9,586	68,562	54,094	28,556
Halifax Allocation	2,255	4,323	5,005	4,785	3,747	4,177	4,188	2,920	2,427	1,959	1,066	1,884	2,051
Glace Bay	13,116	n/s	240	500	100	8	51	n/s	50	n/s	n/s	n/s	51
Bras d'Or Lakes	300	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s

n/s - no survey; *original allocation of 2,387t was increased by 400t

Southwest New Brunswick Migrant Juveniles

The New Brunswick weir and shut-off fishery catches migrant juvenile herring. In 2016, landings increased from the historical low of 146t in 2015 to 4,060t (Figure 5). Fish caught in the New Brunswick weir and shutoff fishery were primarily juveniles (83% Age 2 and 12% Age 3 by numbers). The number of weirs with catches increased in 2016 to 26 from 11 in 2015.

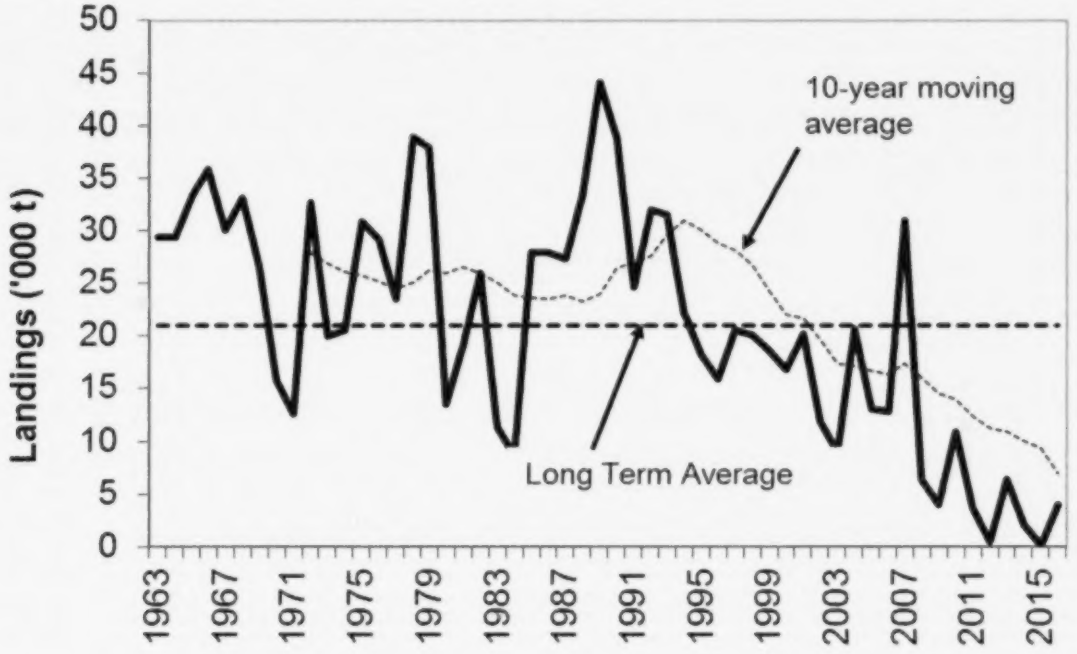

Figure 5. Herring landings from Southwest New Brunswick weirs and shutoff fishery from 1963-2016 with long-term average and 10-year moving average.

Conclusions

Southwest Nova Scotia / Bay of Fundy Spawning Component

The overall acoustic spawning stock biomass estimate for the SWNS/BoF spawning component decreased by 29%. There was an increase on German Bank, but Scots Bay showed a large decrease. There is uncertainty in the acoustic biomass estimates, and the 2016 data were inconsistent with the long-term trends. There is an increasing trend in Scots Bay between 2005 and 2015 with a decreasing trend in the German Bank area from 1999 to 2015. In 2016, there was an increase in the German Bank biomass from the historical low recorded in 2015. The trends indicate that continued caution is warranted. The SSB for Trinity Ledge remains low relative to values observed in the early 2000s.

The 3-year moving average decreased again in 2016 and, as such, continued caution is warranted. Overall, the broad age ranges observed in the commercial catch indicates that this conservation objective is generally being met. A summary of the observations and conclusions for each of the corresponding objectives in the IFMP are presented in Table 5.

Table 5. Observations and conclusions on conservation objective elements from the management plan for SW Nova Scotia / Bay of Fundy spawning component in 2016.

Objectives in Management Plan	2016: Observations and Conclusions
Persistence of all spawning components	Spawning observed in Scots Bay and German Bank. Spawning activity could not be determined on Seal Island or Browns due to a lack of fishing or survey effort. Trinity Ledge had minimal spawning documented.
Maintain biomass of each component	There was an increase on German Bank, but Scots Bay showed a large decrease. There is uncertainty in the acoustic biomass estimates, and the 2016 data were inconsistent with the long-term trends. There is an increasing trend in Scots Bay between 2005 and 2015 with a decreasing trend in the German Bank area from 1999 to 2015. In 2016, there was an increase in the German Bank biomass from the historical low recorded in 2015. The SSB for Trinity Ledge remains low relative to values observed in the early 2000s.
Maintain broad age composition	Currently, broad ranges of ages are in the commercial landings (2-9), as well as in the acoustic surveys catch-at-age (3-11). In 2016, there was a general decrease in terms of numbers and weight for ages 2, 4 and 6+ when compared to 2015. Ages 7+ decreased from 15% in 2015 to 10% in 2016. Since 2010, there has been an increase in proportion of fish Age 6 and older in the acoustic catch-at-age.
Maintain long spawning period	Start of spawning in 2016 for both Scots Bay and German Bank was a few days later than in 2015 based on survey results. An earlier end date is also seen in Scots Bay and German Bank. Very little spawning occurred on Trinity Ledge.
Fishing mortality at or below $F_{0.1}$	Fishing mortality could not be determined. Relative exploitation rates based on acoustic SSB and landings increased in 2016 when compared to 2015.
Maintain spatial and temporal diversity of spawning	Spawning in the German Bank area displays a trend of an earlier end date. Spatially, the German Bank area had a similar distribution to previous years. In 2016, duration of spawning in Scots Bay was similar to previous years. Spatially, the Scots Bay area had a similar distribution as in previous years. Therefore, spawning periods are being maintained both temporally and spatially on the two major spawning grounds Trinity Ledge spawning is very restricted in space and time.
Maintain biomass at moderate to high levels	The overall acoustic biomass estimates decreased to 26% below the long-term average (1999-2016). Most of the decrease occurred in Scots Bay (59%) down from the record high in 2015. The German Bank SSB increased from the historic 2015 low by 20%.
Maintain 3-year moving average above the limit reference point	The 3-year moving average for the acoustic surveys estimate (Scots Bay and German Bank combined) has recently decreased from being 13% above the LRP in 2014 to being 11% above in 2016. As a result, the value of the 3-year moving average in 2016 also decreased from 2015 resulting in a downward trend in the last two years. This trend is a cause for concern and current management measures may not be adequate to meet the rebuilding plan objectives.

Offshore Scotian Shelf Spawning Component

There was a decrease in the landings from the offshore banks from 1,803t in 2015 to 1,035t in 2016. In the absence of recent information about stock status, there is no basis for evaluating the current catch allocation of 12,000t. Structured acoustic surveys are needed to obtain data on the stock in the offshore area.

Coastal Nova Scotia (South Shore, Eastern Shore and Cape Breton) Spawning Component

Decreases in biomass estimates were recorded for both Little Hope and Eastern Shore areas in 2016. However, while the Little Hope biomass was below the average for the last 5 years, the Eastern Shore biomass was well above. There has been no research or acoustic surveys

completed in the Bras d'Or Lakes since 2000. It is recommended that this area remain closed to herring fishing until there is evidence to demonstrate a recovery.

Southwest New Brunswick Migrant Juveniles

The landings in the weir and shut-off fishery in 2016 increased from the 2015 historical low. The degree to which this reflects abundance is unknown.

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Sources of Information

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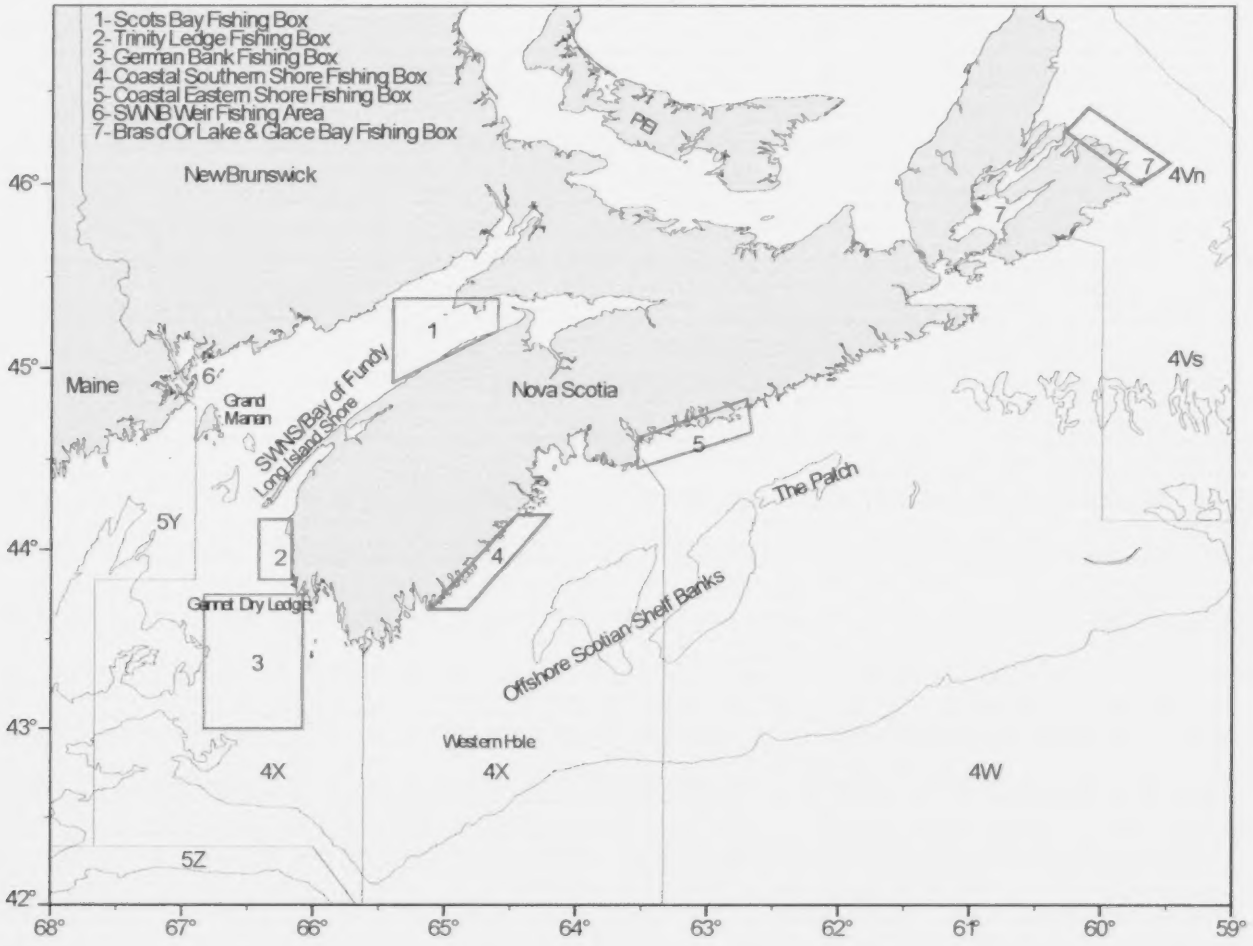
Appendix

Appendix 1. Place names and fishing locations for Southwest Nova Scotia/Bay of Fundy, coastal NS (South Shore, Eastern Shore, Cape Breton), Offshore Scotian Shelf and SWNB weirs. The vertical line between the two 4X labels indicates the outer boundary of the SWNS/BoF stock component.



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